Remarks for 56th International Astronautical Congress

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Thank you, Mr. Takayanagi, for that generous introduction, and good afternoon ladies and gentlemen. I am honored to present NASA's visions and plans for the next 20 years in the exploration and utilization of space alongside my distinguished colleagues from Canada, China, India, Japan, Russia and the European Space Agency, and to such a knowledgeable audience.

To preface my remarks, let me say as someone who's been privileged to work in the aerospace business for almost 35 years, that it is remarkable how far we've come in less than 50 years of activity in space.

Twelve human beings have explored the surface of the moon; it is now my job to make that number grow by leaps and bounds. The world's spacefaring nations have sent robotic pathfinders to all of the planets of our solar system, with the exception of Pluto, and if we are able to launch New Horizons in January 2006, we'll have one on the way to that planet, as well. In just 10 years, over 150 planets beyond our solar system have been discovered, and there are indications that at least one has the same rocky characteristics of our home planet. And closer to home, our citizens have reaped enormous benefits from communications, navigation, weather, and other remote sensing satellites.

But as much as we can take pride in these accomplishments, the dawn of the true space age lies ahead of us. In a relatively short amount of time, I believe people around the globe will be able to look up at new Moon, and with the aid of a strong telescope, be able to see the glimmering lights of a research station on the lunar surface manned by an international crew. At this research station, pioneering astronauts will be learning how to obtain useful resources such as oxygen from the lunar regolith. They will be deploying small antennas on the back side of the Moon, which can be linked in phase to form the largest radio telescope ever built, free of radio noise from Earth. They will be engaged in geological exploration of the Moon, finally establishing the origins of our Earth-Moon system. And other astronauts, elsewhere, will be readying a 500 ton spaceship for mankind's first voyage to Mars.

Indeed, in the century that is just beginning to unfold, we will see human civilization begin to spread out into the Solar System, perhaps sooner than many people expect, as the result of a lot of hard work by the world's space agencies. I believe that NASA will be in a position to advance much of that progress. Twenty months ago President Bush gave NASA a defining challenge and a new direction through the Vision for Space Exploration. The Vision commits our nation to a new journey of exploration of the solar system, beginning with a return of humans to the Moon by the end of the next decade, and leading to subsequent landings of pioneering astronauts on Mars.

In presenting the Vision, the President made clear that while he was determined to carry out the pioneering tradition the American people hold dear in our hearts, this new journey would involve extensive international cooperation. The President stated, "We'll invite other nations to share the challenges and opportunities of this new era of discovery. The vision I outline today is a journey, not a race, and I call on other nations to join us on this journey, in a spirit of cooperation and friendship."

But as much as there is cause for great optimism about what can be accomplished as we undertake this journey, there will always be those who call for the world's spacefaring nations to turn inward, to retrench and focus our energies on pressing issues of the day. And, it is true, there *are* always pressing issues. So, why should we be doing this? The "why" of space exploration is a question that we in the space community have been trying to answer in a compelling way for a very long time. It is a difficult thing to do.

I recall that Louis Armstrong once said about jazz music, "if you have to ask what jazz is, you'll never know". Similarly, when frustrated, I have at times been moved to say that if you have to ask why we should explore space, you'll never understand the answer.

But this is not good enough. If we in the space community expect to lay a legitimate claim to even a very small portion of public financial support in our various nations, we must justify those claims in a way that others, not of our community, can understand.

I have come to believe that part of the difficulty is that there may be no single compelling rationale for space exploration. Instead, there are a number of rationales that are compelling to different people for different reasons.

I think President Bush expressed well one of the core reasons for what we do, when he eloquently stated, "The cause of exploration is not an option we choose; it is a desire written in

the human heart." Or in other words, the spirit of exploration is something embedded in our human DNA. In a certain sense, this must be true, or the human species would still be confined to East Africa, if it existed at all. And indeed, this genetic trait must lie even deeper than the human species; most members of the animal kingdom range as far and wide as their physical adaptability allows. So, while exploration beyond one's known habitat is usually difficult and dangerous for an individual, it clearly provides survival value for the species as a whole, in the longer run. And, in the very long run, this may indeed be the single most compelling reason for space exploration. Carl Sagan captured it nicely when, in his usual droll manner, he noted that if the dinosaurs had had a space program, they would not be extinct.

But, no less than the species as a whole, individual human civilizations and cultures exhibit the desire to survive, grow, and prosper. We see plainly from the evidence of history that those nations that have made a sustained commitment to exploration have prospered in the long run. Each of the nations represented on this panel can proudly relate the role that exploration has played in their history, both materially and culturally. Certainly the American people are very proud of the United States' role in the history of spaceflight, a role that links modern America to our history as a frontier nation. In public opinion polling, a strong majority of our public supports the goals of this program. This popular support is reflected in the fact that huge majorities of both houses of our Congress have voted to fund the program that President Bush has laid out. In the end, societies that commit to the frontiers of their time prove, in retrospect, to be among the leaders of that time. Space exploration is the frontier of our time.

One of our country's great statesmen, Senator John Warner of Virginia, recently submitted an amendment to legislation that addressed another reason for promoting human spaceflight. "Human spaceflight," he asserted, "provides unprecedented opportunities for the United States to lead peaceful and productive international relationships with the world community in support of United States security and geo-political objectives." I can tell you from my perspective, we are tremendously appreciative of the opportunity that the ability to work with other nations has afforded us on projects such as the International Space Station. The ISS partnership has endured many strains over the years since it was formed, and is coping now with the aftershocks from the loss of the Space Shuttle *Columbia* in 2003. Yet it remains strong. This cooperative endeavor serves as a model for what we can accomplish as we look ahead. If great nations seek out the

great endeavors of their time, they do it best with allies and partners. Space exploration is the great endeavor of our time.

And while it is trite to say it, we must observe that in the process of exploring space we develop impressive new technologies and capabilities that benefit billions of people here on Earth. Just as Project Apollo led to important advances in computing and electronics, the potential technological benefits from an expansive 21st century exploration program could prove considerable. The technology development necessary to execute and implement our long-range exploration program will accelerate advances in robotics, autonomous and fault tolerant systems, human-machine interfaces, materials, life support systems and novel applications of microdevices, to name a few. Space exploration is a lens which brings a focus to the development of key technologies in a way that simply would not occur without the "demand pull" that arises when trying to accomplish the near-impossible.

With all these reasons in mind, I believe that we can address the immediately pressing needs of human societies while, with a modest investment of our national resources, continue the exploration activities that help fuel the growth of human creativity, innovation and technology development.

I wish to now tell you how NASA plans to carry out our nation's goals, and to discuss the many opportunities we see for international participation in our exploration program.

Let me first stress that in this business the opportunity to move forward with bold exploration goals, with a system architecture that supports those goals, happens once in a generation. So we are quite cognizant of the need to be both practical and far-reaching in our actions. We are determined to create an operational flexibility with new spacecraft and systems that can operate in the vicinity of Earth and also enable us to travel to and from the surface of the Moon and Mars. In fact, when we designed the systems that will help us achieve our objectives, we began with Martian activities as a fundamental goal, and worked back from there.

NASA's Space Exploration Architecture

So what are the next steps?

Please allow me to give you some insight into how we propose to accomplish the job of getting back to the moon, perhaps as soon as 13 years from now, and then conduct the first

human exploration of Mars. I want to list some of the characteristics of the new exploration systems we will develop.

The new generation of spacecraft, launch vehicles and related systems will build upon the foundation of proven designs and technologies used in the Apollo and Space Shuttle programs, while having far greater capacity and capability. They will be able to carry larger and heavier cargos into space, carry more people to the Moon than Apollo, and remain for longer periods of time. Space will no longer be a destination visited briefly and tentatively. We will learn to live off the land.

As mentioned, we will develop two basic launch vehicles – one for crews and one for heavy cargo, in addition to our lunar landing vehicle. Transporting crew in a separate, smaller vehicle is safer and more efficient than flying crew and cargo together, as the Shuttle does. Fundamentally, the Crew Exploration Vehicle will be many times safer than the Shuttle because it will sit on top of its propulsion system and have a launch escape capability.

Our lunar flight plan is based on that of the Apollo program, but the lander will carry four astronauts to the surface instead of two, with the crew exploration vehicle remaining in lunar orbit on autopilot. As many of you are aware, the Apollo landers could only go to areas relatively near to the lunar equator. The new lunar exploration system will provide the capability to land and conduct exploration activities anywhere on the moon, including on the far side, and in polar regions that may contain water ice and other resources the astronauts could use at a base camp.

In all of our planning, we wanted to ensure that we will develop a core transportation system that gives us a capability to go to Mars. Knowledgeable analysts have concluded that a Mars-class spaceship will weigh on the order of 500-600 metric tons. We intend to use the Shuttle-derived heavy lifter we are developing for missions to the moon to support the assembly in low Earth orbit of a spaceship for a Mars voyage. With the heavy lifter, we can assemble a Mars spaceship in a matter of a few months, with no more than a half-dozen assembly flights, utilizing the historic launch complexes 39-A and -B at the Kennedy Space Center.

With the retirement of the Space Shuttle looming in 2010, we believe that the United States must develop these capabilities so that we can continue to have assured access to near-Earth space, and the ability to mount our more expansive exploration program. There will be, however, opportunities for international involvement in this segment of NASA's planned

activities. In fact, two European aerospace companies are currently members of the U.S.-led teams competing to develop our new Crew Exploration Vehicle.

International Cooperation

I'd now like to share our thinking about other opportunities for international cooperation in this effort. Significantly, international participation in the Vision already exists. The utilization on the International Space Station of impressive capabilities provided by our partner nations, the flight of international astronauts on the Space Shuttle, and the planned launch of international laboratories and additional infrastructure are high visibility examples of this cooperation.

As the United States conducts an orderly phase out of the Space Shuttle program, we anticipate that NASA will rely to a greater extent on Russia, Europe and Japan for Station resupply capabilities.

Let me also state clearly that NASA remains committed to working closely with our international partners to maximize the research potential of the International Space Station. We view what can be learned onboard the International Space Station as vital to helping human crews overcome the physical, mental and emotional challenges of long duration human spaceflight, including those that will explore worlds well beyond low Earth orbit.

Turning to international cooperation in robotic space science activities, coordinated Mars reconnaissance missions are currently underway together with other highly successful cooperative planetary exploration missions such as Cassini-Huygens. ESA's Huygens probe, which provided us with our first-ever in-situ reconnaissance of Saturn's moon, Titan, is worthy of particular note.

Significant international participation from Canada and Europe is also anticipated in NASA's Mars Science Lab and Phoenix missions. In addition, a Russian neutron detector is part of NASA's Lunar Reconnaissance Orbiter, and NASA has two instruments on India's lunar mission, Chandrayaan-1. Current discussions with Europe on SMART-1 and Japan on SELENE are considering these lunar missions for collaboration.

The future cooperation we are anticipating builds on the fact that out of NASA's 64 ongoing planetary exploration, astronomy and Earth observing satellite and spacecraft missions, 34 include international participation.

Our recent announcement about plans for our next generation of spacecraft and launch vehicles focused primarily on the near-term development of the necessary core crew and cargo

transportation systems. We believe that a prime opportunity for international cooperation exists for the development of facilities for use on the moon or Mars. In this regard, potential opportunities include:

- Logistics resupply for the International Space Station.
- Coordinated lunar robotic missions that will prepare us for and support us in landing and operating on the Moon's surface.
- Cooperation on a variety of lunar surface systems and infrastructure, including lunar habitats, power and science facilities, surface mobility units such as rovers, logistics and resupply, communications and navigation, *in situ* resource utilization equipment, and compatible backup life support systems.

I would add that our collective experience with Antarctic research gives us a tremendous model for the kinds of internationally-crewed research bases we can construct on the Moon within the two-decade period this conference is considering.

We also look forward to working with the other spacefaring nations on activities that will enable the first pioneering crews to explore the surface of Mars. One can easily imagine such cooperation will include work on analogue or ground based research—work that is already engaging some of the world's best scientists in figuring out under what conditions life forms may exist throughout the universe—on compatible transportation resources, on Mars precursor science missions and the preparation for joint human missions to Mars.

In these ways we hope to promote common space exploration objectives and cooperative or complementary space exploration missions, along with the development of breakthrough technologies that will open up many opportunities for exploration and discovery.

In the months ahead, I am confident that we will achieve steady progress in reaching our exploration objectives—one mission, one voyage, and one landing at a time.

Finally, I'm convinced that in the ways we are attacking the challenges presented by the Vision, we are setting the stage for a space program that will increase the opportunities we will all share to advance scientific knowledge and expand humanity's exploration horizons.

Once again, I thank you for the opportunity to speak to this distinguished gathering, and I looking forward to working with many of you in the future as NASA continues its great exploration journey.